Cadmium Kinetics in *Lithobius forficatus* (L.) during Experimental Contamination and Decontamination

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ABSTRACT

Experiments were conducted on adult mature *L. forficatus* specimens collected in an area of Northern France contaminated by various metals (Al, Cd, Cu, Pb). The mean level of cadmium in the soil reached about 60 ppm. Kinetics of decontamination, performed in autumn experiments showed a decrease in Cd level in centipedes, from about 30 ppm at the beginning of the experiment to about 12 ppm ten weeks later. Kinetics of contamination, starting after a period of decontamination, showed at first a dramatic increase in Cd levels (up to a mean 80 ppm), followed by a decrease, although the animals were regularly fed with cadmium contamined larvae. Difference between animals fed or not with cadmium containing diet ranged from 18 ppm to only 8 ppm at the end of the experimental series. Experiments conducted either in autumn or spring showed comparable evolution of level curves, if not the same values.

RÉSUMÉ

La cinétique du cadmium chez *Lithobius forficatus* (L.) au cours d'une expérience de contamination et de décontamination.

Des expériences ont été menées chez des adultes de *Lithobius forficatus* prélevés dans le Nord de la France, dans une zone contaminée par divers métaux (Al, Cd, Cu, Pb). La cinétique de décontamination, suivie expérimentalement durant l'automne, montre une diminution des taux de 30 ppm au début à environ 12 ppm dix semaines plus tard. Les cinétiques de contamination, débutant après une période initiale de décontamination montrent dans un premier temps une augmentation importante des taux atteignant 80 ppm. Une décroissance régulière des taux est ensuite observée, alors que les animaux continuent à recevoir une nourriture contaminée par le cadmium. A la fin de l'expérience, la différence entre les animaux nourris ou non avec de la nourriture cadmiée est d'environ 10 ppm. Aux valeurs près, l'expérimentation, qu'elle soit automnale ou printannière, montre les mêmes phénomènes.

INTRODUCTION

Pollution by heavy metals is one of the main ecological problems of industrial areas, at least for invertebrates (HOPKIN, 1989). In Northern France, numerous metal works were closed during the last 20 years, and after demolition of furnaces and buildings, the resulting industrial wastelands were rehabilited. Part of such a wasteland, located in Mortagne du Nord, previously a zinc works, was used as an experimental area.

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It has been shown in a previous work (HOPKIN *et al.*, 1985) that chilopods are one of the invertebrate groups that is common in metal contaminated areas. Despite studies concerning the rate of assimilation of heavy metals by *Lithobius variegatus* (HOPKIN *et al.*, 1985; HOPKIN & MARTIN, 1984), and some other soil arthropods (JANSSEN *et al.* 1991), no data exist about the dynamics of accumulation and detoxication of metals in centipedes.

The present study is part of a program initiated by "Espace Naturel Régional du Nord Pas de Calais" about the biology and evolution of industrial wastelands.

MATERIAL AND METHODS

Animals

Mature adults *Lithobius forficatus* (L.) were collected on the metalliferous grassland located in Mortagne du Nord. For some experimental series, animals of the same subareas were collected separately, the level of cadmium varying according to the place of sampling (reported as "A" [lawn], "B" [stub] and "C" [mixed poplar-willow-birch woodland] in the corresponding graph).

In the lab, the centipedes were fed with *Chironomus* larvae bought at a fisher supplier and maintained either in tap water or in water containing 20 mg/l of $CdCl_2$. When used for feeding, the Cd mean level of the latter was 150 mg/kg. Animals were starved for 3 days before analysis in order to ensure digestion and to not measure the gut content.

Each point of the decontamination or of the experimental contamination curve resulted from four to five animals analysed individually.

Mineralization

Animals were dried at 80°C (12 hrs) and weighed. The samples, reduced to powder, poured into test tubes and added with 1 ml HNO_3 (Normapur) were kept at room temperature. Samples were then warmed up to 120°C and kept at this temperature till half the acid mixture was evaporated. 1 ml of a mixture of HNO_3 - H_2SO_4 - $HClO_2$ (10v/2v/3v; Normapur grade) was then added and warmed up to 180°C. When half the solution was evaporated, the resulting mixture was diluted to 20 ml with deionized water.

The digests were analysed for cadmium by flame (Perkin Elmer 2380) or flameless (Varian AA 300) atomic absorption spectrophotometry. Results are expressed hereafter in mg of cadmium per kg of dry mass.

RESULTS

The mean level in soil was about 40 mg/kg of Cd (ranging from 6 to 76 mg/kg), i.e more than one hundred fold higher than in agricultural soils of Northern France (0.32 mg/kg, data from "Chambre d'Agriculture du Nord", October 1990). As a consequence, animals contained more cadmium than those collected in unpolluted sites (for example, 4.2 mg/kg in another site located in St-Amand, some kilometers southwest of Mortagne *versus* 10 to 30 mg/kg).

Animals fed with unpolluted diet showed a decrease of the level of Cd, as shown by the slope of the linear regression (Fig. 1), evidence for the existence of a detoxication process. Animals fed with Cd polluted diet (after a period of unpolluted feeding) showed a dramatic increase of the Cd level during two weeks, and then decreased values were recorded, with a rate of elimation far higher than that observed in controls (Fig. 2).

At the end of the experimental series, the values recorded in the two kinds of animals were not so different (Fig. 2), controls ranging from 8 to 14 mg/kg and Cd fed animals about 20 mg/kg.

In experiments conducted during spring, only experimental contamination was performed, after about two weeks of natural detoxication in the lab. The same shape of curve was observed, as in autumn experiments: a dramatic increase followed by active decontamination (Fig 3). In this particular case, the area of collection of animals was recorded, so we were able to demonstrate the variations observed from one animal to another, according to the sample site (Fig. 4).

Concerning the assimilation rate of Cd, we have indirect evidence for a quick elimination or, at best, a non assimilation at the time of feeding. Indeed, based on the mean Cd level of the diet, an animal ingested about 5.5 µg Cd per week and the maximum level recorded a week after the beginning of polluted feeding reached a mean 80 mg/kg of dry weigh, corresponding to about 1.6 µg of Cd per centipede, i.e. 1 µg more than at the beginning of the experiment.

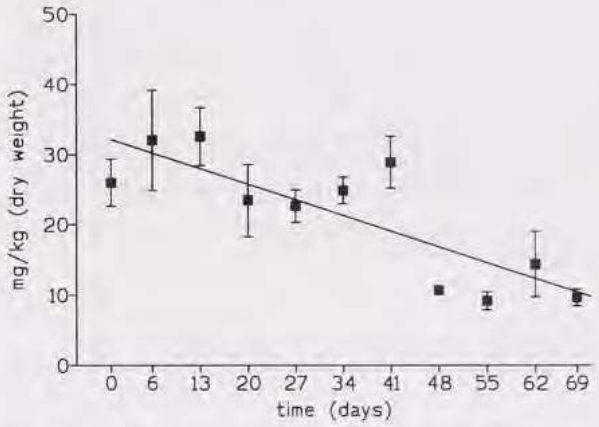

FIG. 1. — Elimination of cadmium in *L. forficatus* fed with unpolluted diet. Original data are given as means with SEM. Solid line: linear regression.

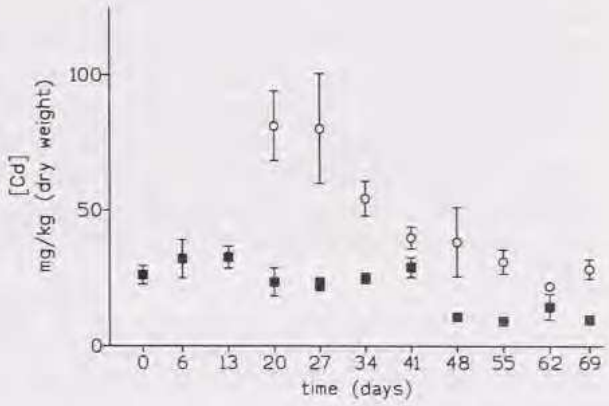

FIG. 2. — Accumulation and elimination of cadmium in *Lithobius*. Black squares: animals fed with unpolluted diet (same animals as in Fig. 1); open circles: animals fed with Cd polluted diet (starting on day 15). Means ± SEM.

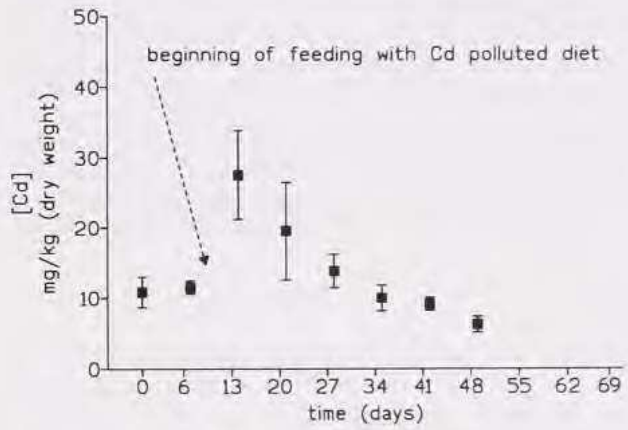

FIG. 3. — Accumulation and elimination of cadmium in *Lithobius* during spring experiments. Feeding with Cd polluted diet starting on day 9. Means ± SEM.

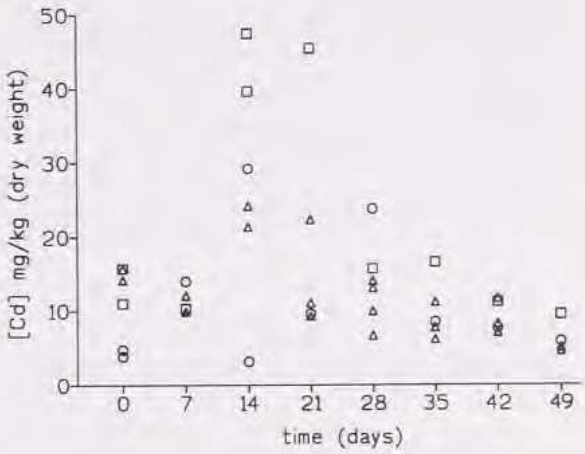

FIG. 4. — Same animals as in Fig. 3, but with individual values according to the sample site (A, B, C; for details, see the text).

DISCUSSION

The first point to discuss is the ability of *Lithobius* to eliminate cadmium. Indeed, we have shown a decrease of the Cd level when animals were supplied with clean diet. This rate of elimination in our autumnal experimental series is about 20 ppm for ten weeks. It must be notice that in spring experiments the level of Cd in animals was a bit lower. This fact may be related to low amounts of metal ingested, consequence of the winter low rate of metabolism and poor feeding.

The second point concerns the dynamics of accumulation: the animals reacted rather quickly to Cd supply. Only two points of analysis show high values: during two weeks the animals accumulate more Cd than they can eliminate. Then, they eliminate more Cd than they assimilate. As the values recorded at the end of experimental series were quite comparable to that measured at the time of collection, we can consider that the latter are equilibrium values for animals when they are in a period of active physiology in metal polluted soil.

The assimilation rate of Cd shown by our results is a little bit higher (about 18%) than the 10% found by HOPKIN *et al.* (1985) but we may keep in mind that the diet was not the same, and that *Chironomus* larvae bring Cd both as compounds linked to the body and as soluble $CdCl_2$ to be found in the water layer surrounding the body.

ACKNOWLEDGMENTS

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